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Producing First-Season Alfalfa on Coastal Plain Soils

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Abstract

Multiple-year alfalfa production on coastal plain soils has been limited due to problems associated with stand persistence and post-harvest handling. One proposed management strategy is to maximize first-year alfalfa yield and quality, placing less importance on multiple-year alfalfa production. The objective of this study was to compare the effect on first-year alfalfa of four harvest intervals based on morphological stage and three harvest intervals based on a fixed harvest schedule. Dry matter (DM) yields, crude protein (CP), neutral detergent fiber (NDF), and in vitro digestibility were measured. First-year alfalfa DM yield ranged from 9,880 to 13,230 lbs/acre when harvested by morphological stage and from 8,860 to 10,200 lbs/acre when harvested on a fixed schedule. Nutritive value measurements showed small, although inconsistent, improvement in forage quality when harvested at either an early morphological stage (10%) or a short fixed interval (4 weeks). With the adoption of balage harvest systems and high quality imported alfalfa hay often approaching $200 per ton, managing alfalfa as a high quality annual, with an expected yield of 5 tons/acre, should be an economically feasible option for many southern forage producers.

Introduction

Alfalfa (*Medicago sativa* L.) is a widely adapted forage species with over 23 million acres harvested for hay in the United States during 2002 (8). However, production of alfalfa is extremely limited in the southeastern US with Louisiana reporting a meager 285 acres of commercial alfalfa hay production in 1998 (7). Alfalfa production has been limited by problems associated with persistence and post-harvest handling. Persistence in this sub-tropical region is associated with inherently acid soils, high insect populations, and numerous fungal pathogens. With increasing use of new harvesting and storage methods, stand persistence has become the limiting factor for alfalfa production on coastal plain soils. One proposed management strategy is to maximize first-year alfalfa yield and nutritive value. This management strategy would place less importance on persistence and multiple-year alfalfa production.

It is well known that forage nutritive value declines and yield increases with advancing plant maturity. Therefore, alfalfa harvest management based on a fixed interval reduced forage yields over short intervals even though nutritive value was enhanced (13). Conversely, studies of harvest management based on morphological stage indicated that harvesting at a more advanced stage of development negatively affected forage nutritive value more than yield (9). Brown et al. (2) found that harvest management based on morphological stage affected seasonal forage yield distribution more than it affected root carbohydrate reserves. Kallenbach et al. (5) observed that neither full-season harvest frequency nor late-autumn harvest frequency influenced stand persistence. However, they did note that certain cultivars selected for increased persistence when grazed had increased persistence over hay type cultivars. Surprisingly, these observed differences in stand persistence did not result in greater forage yield potential among any of the cultivars. Declines in nutritive value do not appear to interact with cultivar. Vaughn et al. (11) showed that alfalfa synthetics, selected for increased nutritive value, maintained a nutritive advantage irrespective of the harvest management.

The primary objective of this research was to determine the potential impacts of different harvest management strategies upon first-year alfalfa forage yield and nutritive value when grown on coastal plain soils.

Experimental Design and Analysis

Studies were initiated to test two harvest strategies: harvesting by morphological stage and harvesting on a fixed schedule. The experimental design for all studies was a randomized complete block with four replications at each location. Yield and quality data were analyzed using SAS PROC ANOVA and PROC GLM (SAS Version 7, SAS Institute Inc., Cary, NC). Fixed effects were harvest interval and cultivar. Random effects included location and replication within location. Mean separations were made using Duncan's multiple range test. All differences reported are at $P < 0.05$ unless otherwise noted.

Harvest Based on Morphological Stage

To determine the effect of first-season alfalfa harvest management based on morphological stage of development (6), studies were established at the Southeast Research Station (Southeast), Franklinton, LA on 13 November 1984 and at the Perkins Road Farm, Baton Rouge, LA on 12 November 1985. Soil types were a Tangi silt loam (Fine-silty, siliceous, thermic Typic Fragiudults) at Southeast and an Olivier silt loam (Fine-silty, mixed, active, thermic Aquic Fraglossudalfs) at Perkins Road Farm. The cultivars Florida 77 and Apollo were drill seeded on 7-inch rows to a depth of ¼ to ½ inches at a rate of 30 lbs/acre into 4-×-16-ft plots at Southeast and 3-×-20-ft plots at Perkins Road Farm. Four harvest interval treatments were used: (i) harvest at 10% bloom all season (treatment designated as 10%), (ii) harvest at 10% bloom (April to June) followed by subsequent harvests at the crown bud stage (10% CB), (iii) harvest at 50% bloom all season (50%), and (iv) harvest at crown bud stage all season (CB).

Plots at Perkins Road Farm were top dressed with 50 lbs/acre phosphorus (P) and 50 lbs/acre potassium (K) on 30 June 1986 and 2 lbs/acre boron (B) on 11 July 1986. Fertilization at Southeast consisted of 10 lbs/acre nitrogen (N), 30 lbs/acre P, and 60 lbs/acre K applied on 7 November 1984 and incorporated prior to planting. Subsequent fertilizer applications consisted of 40 lbs/acre P and 40 lbs/acre K on 8 March 1985; 20 lbs/acre P and 20 lbs/acre K on 12 June 1985; and an additional 20 lbs/acre P and 20 lbs/acre K on 28 August 1985. Eptam herbicide was applied pre-emergence at a rate of 2 pts/acre at both locations.

Forage quality analysis. Forage quality data for 1985 and 1986 were analyzed with near infrared reflectance spectroscopy (NIRS) spectra collected from six filter segments. Calibration equations were developed from 220 alfalfa samples analyzed previously for crude protein (CP), neutral detergent fiber (NDF), and in vitro dry matter disappearance (IVDMD). Forage quality values from this experiment were predicted using NIRS. Fifty-five samples were randomly selected and analyzed using the same wet chemistry procedures used to develop the calibration set. The results of these analyses were used to validate the previously developed calibration functions. Neutral detergent fiber, and IVDMD were measured using the methods of Goering and Van Soest (3).

Results: Forage yield. Mean dry matter yield across environments differed for cultivar and harvest treatment but not environment. However, environment by cultivar and environment by harvest treatment interactions were observed (Table 1). When analyzed by environment, cultivar differences in dry matter yield were observed at Perkins Road, but not at Southeast. This observation can be attributed to the fewer harvests of Apollo at Perkins Road. Harvest-interval differences in dry matter yield were observed at both locations, but harvest interval by cultivar interaction differences were not found. Maximum yield was obtained at Perkins Road Farm when alfalfa was harvested at the 10% or 10% CB intervals (Table 2). Highest yields were obtained with a 50% harvest interval at Southeast, but this yield was not different from the 10%, or CB harvest intervals (Table 2). Yield distribution by harvest across cultivars at both locations for all treatments is shown in Table 3.

Table 1. Mean squares for alfalfa total dry matter yield, crude protein (CP), neutral detergent fiber (NDF), and in-vitro dry matter digestibility (IVDMD) across two environments and four harvest treatments, based on morphological development, in Louisiana.

Source	**df**	**Total Yield**	**CP**	**NDF**	**IVDMD**
Environment (E)	1	95313	1503†	89	7988†
Rep (R)	3	2807931	20	33	154
Treatment (T)	3	7382318†	18	106‡	8
Cultivar (C)	1	20965086†	< 1	< 1	6
E*C	1	18131975†	44	19	28
E*T	3	28186514†	7	9	150
C*T	3	1925098	12	23	138
C*E*T	3	1165968	21	19	29

† $P < 0.05$
‡ $P < 0.10$

Table 2. Mean dry matter yield, crude protein (CP), neutral detergent fiber (NDF), and in-vitro dry matter disappearance (IVDMD) for first season alfalfa harvested at two environments and four morphological stages. Means in the same column within a location followed by common letters do not differ at $P = 0.05$.

Southeast Research Station (1985)				
Treatment*	**CP** (%)	**NDF** (%)	**IVDMD** (%)	**Yield** (dry lbs/acre)
10%	17.6 a	46.0 a	71.3 a	11410 ab
10% CB	17.3 a	45.2 a	70.1 a	10420 b
50%	16.9 a	47.8 a	72.8 a	12170 a
CB	16.6 a	46.7 a	73.5 a	11860 a
Perkins Road Farm (1986)				
Treatment*	**CP** (%)	**NDF** (%)	**IVDMD** (%)	**Yield** (dry lbs/acre)
10%	21.5 b	44.2 b	61.7 ab	13230 a
10% CB	22.6 a	44.4 b	63.0 a	12760 a
50%	21.3 b	47.0 a	60.8 bc	9880 b
CB	20.8 b	46.6 a	59.5 c	10100 b

* **10%** = harvest at 10% bloom all season; **10% CB** = harvest at 10% bloom (April - June) followed by harvests at crown bud stage; **50%** = harvest at 50% bloom all season; **CB** = harvest at crown bud stage all season.

Table 3. Alfalfa dry matter yield (lbs/acre) per harvest at two locations for harvest interval based on morphology. Means by harvest number within a column followed by common letters do not differ at *P* = 0.05.

Harvest No.	Treatment*	Southeast (1985)	Perkins Road (1986)
1	10%	2670 a	4720 a
	10% CB	2780 a	4270 a
	50%	2720 a	3500 b
	CB	2650 a	3450 b
2	10%	1680 b	2550 b
	10% CB	1630 b	2570 b
	50%	2740 a	2710 b
	CB	2710 a	3400 a
3	10%	970 b	2940 ab
	10% CB	1100 b	2580 bc
	50%	1060 b	2300 c
	CB	1710 a	3040 a
4	10%	2000 b	2110 b
	10% CB	2940 a	2860 a
	50%	2190 b	1650 b
	CB	2830 a	520 c
5	10%	2500 a	1450 a
	10% CB	1970 b	960 b
	50%	2180 ab	690 b
	CB	1960 b	--
6	10%	1600 a	--
	50%	1270 b	--

* **10%** = harvest at 10% bloom all season; **10% CB** = harvest at 10% bloom (April - June) followed by harvests at crown bud stage; **50%** = harvest at 50% bloom all season; **CB** = harvest at crown bud stage all season.

Results: Forage quality. Environment differences were observed for CP and IVDMD and treatment differences across environment were observed for NDF ($P < 0.10$). There were no environment by treatment interaction differences for any of the quality parameters (Table 1). Cultivar differences were not significant and no cultivar by environment or cultivar by treatment interactions were observed. Treatment differences for NDF across environment revealed consistently lower values for the 10% and 10% CB versus the 50% and CB harvest intervals, but analysis by environment revealed no differences for either variable at the Southeast Research Station (Table 2). However, significant differences ($P < 0.0001$) were observed at the Perkins Road Farm. The 10% and 10% CB harvest intervals had lower NDF values than the 50% and CB intervals and accounted for the differences observed in the combined analysis. Although analysis across environments revealed no harvest treatment differences for CP and IVDMD, analysis by location revealed treatment differences ($P < 0.01$) at Perkins Road Farm (Table 2). Crude protein values for 10% CB were higher when compared to all other treatments. The highest IVDMD value was also observed in the 10% CB treatment and was significantly different from IVDMD in the 50% and CB treatments.

Harvest Based on Fixed Interval

To evaluate the effect of fixed harvest interval on first-season alfalfa, studies were established in the fall of 1998 at three locations in Louisiana: Idlewild Research Station, Clinton; Macon Ridge Research Station, Winnsboro; and Southeast Research Station, Franklinton. Soil types were a Dexter loam (Fine-silty, mixed, active, thermic Ultic Hapludalfs) at Idlewild; a Gigger silt loam (Fine-silty, mixed, active, thermic Typic Fragiudalfs) at Macon Ridge; and a Tangi silt loam at Southeast. Dolomitic limestone was applied at Idlewild Research Station (2 tons/acre) and at Macon Ridge Research Station (1 ton/acre) prior to planting. A pre-plant fertilizer application of 66 lbs/acre P, 250 lbs/acre K, 2 lbs/acre B, and 20 lbs/acre sulfur (S) was made at Idlewild on 6 October 1998, and an equivalent application was made on 30 June 1999. At Macon Ridge, a pre-plant fertilizer application of 70 lbs/acre P, 140 lbs/acre K, 10 lbs/acre S, and 1 lb/acre B was made on 2 October 1998. A second application of 66 lbs/acre P, 250 lbs/acre K, 2 lbs/acre B, and 20 lbs/acre S was made on 9 July 1999. A pre-plant fertilizer application of 20 lbs/acre N, 60 lbs/acre P, 250 lbs/acre K, 4 lbs/acre B, and 20 lbs/acre S was made at Southeast Research Station on 27 October, 1998. A second application of 100 lbs/acre K, 2 lbs/acre B, and 20 lbs/acre S was made on 2 June 1999.

Eptam 7E herbicide was applied pre-emerge at a rate of 2 pts/acre at Idlewild and 3 ½ pts/acre at Macon Ridge. A tank mix of 2,4-DB at a rate of (1 qt/acre) and Poast (1 pt/acre) was applied post-emerge at Southeast. The cultivars Florida 77 and Cimarron VR were drill seeded on 7-inch row spacing to a depth of ¼ to ½ inches at 20 lbs/acre into 5-×-20-ft plots at Idlewild and Southeast on 29 October 1998 and into 5-×-25-ft plots on 30 November 1998 at Macon Ridge. Harvests were initiated on 14 April 1999 at Idlewild and on 16 April 1999 at Macon Ridge and Southeast. Subsequent harvests were made at 28-, 35-, or 42-day intervals.

Forage quality analysis. For 1999 data, NIRS spectra were collected for each sample with a Model 6500 near infrared reflectance spectrophotometer (NIRSystems, Silver Spring, MD). A library data set consisting of 625 samples previously analyzed for CP, NDF, and in vitro true digestibility (IVTD) was developed. Samples from this experiment were centered and selected using the CENTER and SELECT programs in the NIRS2 (version 3.0) system software (4). Selected samples were compared with the library using the MATCH program. If selected samples from this experiment were not matched by two samples in the library file, then wet chemistry values were used for these samples. Matched samples from the library file and wet chemistry values for alfalfa samples not matched to the library were used to make the calibration data set. Reflectance data were related to the calibration data by using a modified partial least squares regression procedure to develop the prediction equation (10). Samples identified as outliers from the calibration data set were analyzed using traditional wet chemistry methods. Samples in the library file and from this experiment were analyzed for CP colorimetrically (1). Neutral detergent fiber was analyzed using the methods described by Goering and Van Soest (3), which were modified by excluding decalin. Additionally, 2.0 ml of a 2% (w/v) α-amylase solution and 0.5 g sodium sulfite was added at the beginning of the NDF procedure (12). In vitro true digestibility was measured using the methods described by Goering and Van Soest (3).

Results: Forage yield. Analysis of fixed interval harvest effects revealed significant location and harvest treatment effects (Table 4). Dry matter yields were greater at Southeast and Macon Ridge than Idlewild. The 42-day harvest interval resulted in significantly more dry matter yield than the 35- and the 28-day intervals (Table 5). Cultivars did not differ in dry matter yield across locations and there were no harvest interval interactions with cultivar or location, but a location by cultivar interaction was observed. When cultivar differences were analyzed by location, Florida 77 produced more dry matter than Cimarron VR at Idlewild (8,290 vs. 7,620 lbs/acre), while Cimarron VR produced more dry matter yield than Florida 77 at Macon Ridge (10,810 vs. 9,450 lbs/acre). Cultivars did not differ in dry matter yield at Southeast. Yield distribution across harvest dates and cultivars at all locations for all harvest interval treatments is shown in Table 6.

Table 4. Mean squares for alfalfa total dry matter (DM) yield across three locations and three harvest treatments, based on fixed harvest interval, in Louisiana.

Source	**df**	**Total DM Yield**
Location (L)	2	36415631†
Rep (Location)	9	7362571†
Treatment (T)	2	11394459†
Cultivar (C)	1	2596395
L*C	2	15892691†
L*T	4	1879585
C*T	2	823648
C*L*T	4	1634725

† $P < 0.05$

Table 5. Alfalfa dry matter yield, crude protein (CP), neutral detergent fiber (NDF), and in-vitro true digestibility (IVTD) for harvests at three locations across three fixed harvest intervals and for three fixed harvest intervals across three locations. Means in the same column, within a location or harvest interval, followed by common letters do not differ at $P = 0.05$.

	CP (%)	**NDF** (%)	**IVTD** (%)	**Yield** (dry lbs/acre)
Location				
Idlewild	18.9 b	42.3 b	75.0 c	7520 b
Macon Ridge	21.9 a	34.9 c	80.7 a	10130 a
Southeast	18.5 b	46.0 a	79.0 b	10350 a
Interval (days)				
28	20.2 a	42.0 a	79.5 a	8860 b
35	19.4 b	41.5 a	77.6 b	8930 b
42	18.7 b	41.9 a	77.0 b	10200 a

Table 6. First season alfalfa dry matter yields (lbs/acre) per harvest, across three locations and two cultivars, based on a fixed interval harvest schedule. Means by harvest interval within a column followed by common letters do not differ at P = 0.05.

Date	Idlewild	Southeast	Macon Ridge
28-day interval			
15 Apr	2380 a	3150 a	3710 a
13 May	350 d	880 c	1460 c
10 Jun	1330 c	1170c	2150 b
8 Jul	1810 b	3080 a	2270 b
5 Aug	1560 bc	2050 b	
35-day interval			
15 Apr	2400 a	3310 a	3650 a
20 May	780 d	1090 c	2470 b
24 Jun	1790 c	2400 b	2580 b
29 Jul	2110 b	2120 b	1180 c
2 Sep	640 d	700 c	--
42-day interval			
15 Apr	2420 b	3420 a	3840 a
27 May	780 c	1100 c	3300 b
8 Jul	2720 a	3550 a	3760 ab
19 Aug	2550 ab	2640 b	--
1 Oct	430 d	440 d	--

Results: Forage quality. Location and harvest interval effects were observed for CP, NDF and IVTD (Table 5). There were no location interactions for any of the variables observed. The highest CP and IVTD values, and the lowest NDF values, were observed at the Macon Ridge Research Station. Crude protein and IVTD values were highest for the 28-day harvest interval. No differences were observed between the 35- and 42-day harvest intervals for any of the quality variables observed. A cultivar effect was observed for CP and IVTD. Cimarron VR had greater CP content (19.9%) than Florida 77 (19.1%). Similarly, IVTD was higher for Cimarron VR (78.9%) than Florida 77 (77.4%).

Conclusions

This research demonstrates that across five environments it was possible to consistently produce 5 tons of quality alfalfa on coastal plain soils. Greater differences in quality and yield were observed among environments than among harvest treatments. The effect of harvest interval based on morphological stage was not as clear as anticipated. Yields were not improved by harvesting at late maturity and harvesting at early maturity did not consistently enhance forage quality. Stand persistence following the first harvest year was not monitored for the studies based on morphological harvest interval, but data was collected for stand persistence in the year following first-season harvest based on a fixed harvest interval. Although harvesting at the 28-day interval resulted in increased CP and IVTD, yields were reduced relative to the 42-day interval (Table 2) and stands were hurt severely in the second year (*data not shown*). If stands are to be maintained longer than one year, it may be critical to harvest at an interval no less than 35 days. Harvesting at 42-day intervals did not reduce quality relative to the 35-day interval and yield was increased. However, given the critical need for high quality summer forage in the southeastern US, second year persistence may not be as important as maximizing first year quality. With the adoption of balage harvest systems and high quality imported alfalfa hay often approaching $200 per ton, managing alfalfa as a high quality annual, with an expected yield of 5 tons/acre, should be an economically feasible option for many southern forage producers.

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